THE RAIN-BEARING WINDS AT KNOXVILLE, TENNESSEE

By STERLING BUNCH

[Weather Bureau, Oklahoma City, Okla., January 1936]

The present paper is intended to be comparable to previous ones by Von Hermann for Atlanta, Ga.,[1] and by Thos. R. Reed [2] for the western United States.

The term "rain-bearing wind" connotes a current of air *from* which or *through* which rain is falling. In this paper, we shall consider "rain-bearing wind" to mean any surface wind which is accompanied by rain; it is obvious, however, that any study based on surface observations alone will not tell much about the free-air conditions involved, and the limitations of this procedure must be kept in mind when attempting to interpret the significance of the results. For the sake of consistency, and because of their rarity, rain-hours with wind calm were not treated separately, but were assigned to the hours just preceding the calm.

The question as to which winds are to be considered the rain-bearing winds at a given locality is somewhat ambiguous; e. g., do we mean only the prevailing direction of the wind during rain? If so, then at a station like Knoxville, where the winds are profoundly influenced by local topography, the prevailing wind over a long period of time will be the prevailing rain-bearing wind. We may mean both the prevailing direction of the wind during rain and the total amount of precipitation contributed by each direction; then we shall want to know, in addition, the average hourly rates for each wind direction, and, most important of all, *the ratio between the total rain-wind-hours and the total wind-hours for each direction.* In the treatment of Knoxville data, four specific questions were considered: (1) What is the prevailing direction of the wind during rain? (2) What wind direction contributes the greatest total amount of rainfall? (3) With what wind direction do the highest hourly rates of rainfall occur? (4) What wind direction is most likely to be accompanied by rain?

The determination of the ratio of total wind-hours to total rain-wind-hours perhaps more nearly eliminates the *mechanical* effect of mountains in changing winds to one or two prevailing directions than could any other approach to the problem based on surface observations alone.

The Knoxville data were tabulated for the 20-year period, 1916 to 1935, inclusive. Only hours with measureable amounts of precipitation were considered, since the *frequencies* and *amounts* would not have been numerically comparable had traces been counted. Precipitation from melted snow contributes less than 2 percent of the total annual precipitation at Knoxville, and the hourly amounts have been estimated. These were counted and given the same weight as the tipping bucket records. The locations of the anemometer and the rain gage during the period considered represent three different elevations and exposures, all in downtown Knoxville.

Knoxville is situated between two mountain ranges, the Cumberlands to the west and northwest with extreme elevations of about 2,000 feet above sea level, and the Smoky Mountains to the east and southeast with extreme elevations of about 6,500 feet above sea level. The valley with an average elevation of about 1,000 feet runs roughly southwest and northeast; and the wind blows from each of these two directions about half the time.

The table contains the results of the investigation. The calendar season is probably not the most desirable time division for such a study; but in this case it was used as a matter of convenience, and because this division happens to agree fairly well with the changes in prevailing winds and rainfall at Knoxville. To simplify the table the totals of wind-hours and rainfall amounts are not included.

During the spring and summer the rain-wind frequencies and rain-fall amount percentages follow closely the wind frequencies; but during the autumn months the number of rain hours is approximately the same for the prevailing northeast winds and for the southwest wind, while the greater amount of rainfall still comes with a southwest wind as during the two preceding seasons. A different picture is presented, however, during the winter months.

Without considering the hourly rates and the rain probabilities with a given wind, we should conclude that only the southwest and northeast winds are of any importance in producing rain over the Tennessee Valley at this point; but when we glance at the last two rows under each season and for the year as a whole, we find that the northeast wind loses its importance as a wet wind and the southwest wind becomes the driest wind that blows.

The hourly rate of the southeast rainfall during the spring and summer is possibly too high because a few excessive falls accompanying thunderstorms happened to occur with a southeast wind. This seems to be borne out by the fact that the southeast wind shows no such excessive variation in rate during the autumn and winter months. On the other hand, this excessive rate may be real and directly due to the thunderstorm winds, since the northwest wind shows an hourly rate for these seasons almost as high. Unfortunately, sufficient data are not available for determining the prevailing direction of translation of thunderstorms in the Tennessee Valley. In any case, the prevailing winds at Knoxville are certainly not the "wettest" winds. During the spring and summer the heaviest rains occur with southeast and northwest winds, during the autumn, with a west wind, and during the winter, with a south wind, although the variation in hourly rates between directions in winter is too small to be significant.

The spring wind most likely to be accompanied by rain is again southeast, with 11.7 hours of rain per 100 hours of wind, but the northwest wind is a close second. In the summer the northwest wind becomes the most probable rain wind, although with only a slight fraction over the south and southeast winds. During the autumn months the west wind is the most likely rain-wind, and during the winter, the south wind.

For the year as a whole, 7.2 hours of rain occur every 100 hours, and falls at an average rate of 0.08 inches per hour. The southwest wind contributes the largest number of rain-hours and also the highest total rainfall, simply because that is the prevailing wind. The southeast wind appears to bring the heaviest falls, bearing in mind what has already been said with regard to a possible purely fortuitous factor in this tabulation; and finally, when the wind blows from northwest in this valley it is more likely to be accompanied by rain than any other wind.

The writer wishes to express his appreciation to both Mr. J. E. Stork and Mr. J. E. Sanders, of the Knoxville

[1] The Rain-bearing Winds of Atlanta, Ga., MONTHLY WEATHER REVIEW, 53: 494–497, 1925.

[2] Rain-bearing Winds in the Far Western States, MONTHLY WEATHER REVIEW, 55: 228–233, 1927.

Weather Bureau Office, the former for his assistance in tabulating the data, and the latter for checking and general criticism of the manuscript.

The rain-bearing winds at Knoxville, Tenn., 1916–35, inclusive

Direction	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Annual
SPRING									
Prevailing wind (percent)	14	18	7	3	9	31	11	7	------
Prevailing rain-wind (percent)	12	20	9	4	11	25	10	9	27
Total amount of rain (percent)	11	19	9	6	11	24	11	9	27
Average hourly rate (inches)	.07	.07	.08	.10	.08	.07	.08	.07	.08
Ratio of rain-hours to wind-hours (hours per 100 hours)	6.5	8.5	9.0	11.7	9.8	6.1	6.9	10.3	7.7
SUMMER									
Prevailing wind (percent)	13	19	9	4	11	30	10	4	------
Prevailing rain-wind (percent)	8	14	9	5	14	32	12	6	17
Total amount of rain (percent)	11	15	8	8	13	25	11	9	28
Average hourly rate (inches)	.15	.13	.11	.20	.11	.10	.12	.18	.12
Ratio of rain-hours to wind-hours (hours per 100 hours)	3.3	3.7	5.3	6.5	6.5	5.4	6.0	6.7	5.7
AUTUMN									
Prevailing wind (percent)	14	28	10	4	8	21	9	6	------
Prevailing rain-wind (percent)	10	24	10	5	8	24	12	7	19

The rain-bearing winds at Knoxville, Tenn., 1916–35, inclusive—Con.

Direction	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Annual
AUTUMN—continued									
Total amount of rain (percent)	9	21	11	4	9	25	14	7	18
Average hourly rate (inches)	.07	.06	.08	.07	.08	.08	.09	.07	.07
Ratio of rain-hours to wind-hours (hours per 100 hours)	3.8	4.8	5.4	6.4	6.0	6.6	7.4	6.8	5.6
WINTER									
Prevailing wind (percent)	14	24	7	2	6	30	10	7	------
Prevailing rain-wind (percent)	13	31	8	2	8	21	10	7	37
Total amount of rain (percent)	13	32	9	2	9	19	9	7	27
Average hourly rate (inches)	.06	.06	.06	.06	.06	.05	.06	.06	.06
Ratio of rain-hours to wind hours (hours per 100 hours)	9.5	13.6	11.0	11.6	15.0	7.5	9.7	11.2	10.5
YEAR									
Prevailing wind (percent)	14	22	9	3	8	28	10	6	------
Prevailing rain-wind (percent)	11	24	9	4	10	25	10	7	100
Total amount of rain (percent)	11	22	9	5	11	23	11	8	100
Average hourly rate (inches)	.08	.07	.08	.10	.08	.07	.08	.08	.08
Ratio of rain-hours to wind-hours (hours per 100 hour)	6.2	7.7	7.4	8.5	8.7	6.4	7.5	9.0	7.2

ANALYSES OF RAINS AND SNOWS AT MOUNT VERNON, IOWA, 1936–1937

By NICHOLAS KNIGHT

[Cornell College, Mount Vernon, Iowa, June 1937]

The analysis of the rains and snows at Mount Vernon, Iowa, was continued during 1936 and 1937. There were 36 samples of rain and only 6 samples of snow. We considered that 1 inch of rain on an acre weighs 226,875 pounds.

The snowstorm of December 5, 1936, was preceded by several weeks of drought, a possible explanation of the high chlorine and nitrate content of the snow. The storm of January 2, 1937, was mostly rain mixed with some snow, while the storm of January 6 contained some sleet; and on January 8 a considerable quantity of rain came down with the snow. The precipitation of January 20 was rain and sleet. The large amounts of chlorine in the precipitation of February 17 and 20 seemed to be due to the duststorms of that period. The rain of April 30 was accompanied by severe thunder and lightning. The storm of May 4 was accompanied by thunder and lightning and there was considerable hail. There was also much thunder and lightning with the rain of May 11.

The rains and snows of Mount Vernon, Iowa, 1936–37

PARTS PER MILLION

No.	Date 1936–37	Precipitation: Amount	Precipitation: Kind	Chlorine	Free NH_3	Alb. NH_3	N in nitrate	N in nitrite	Sulphate
		Inches							
1	June 14	0.12	Rain	3.55	0.64	0.36	1.0	0.01	0.0005
2	June 16	.40	---do	3.55	.28	.48	1.5	.015	.0003
3	Oct. 20	.33	---do	2.15	.42	.20	.9	.012	.0002
4	Nov. 1	.80	---do	5.00	.45	.60	.15	.020	.00
5	Nov. 2	.40	---do	3.50	.32	.45	.10	.03	.0004

The rains and snows of Mount Vernon, Iowa, 1936–37—Continued

PARTS PER MILLION—Continued

No.	Date 1936–37	Precipitation: Amount	Precipitation: Kind	Chlorine	Free NH_3	Alb. NH_3	N in nitrate	N in nitrite	Sulphate
		Inches							
6	Nov. 8	2.00	Snow	2.13	0.60	0.40	0.13	0.03	0.0003
7	Dec. 5	6.00	---do	7.10	.36	.40	1.00	.02	Trace
8	Dec. 26	.75	Rain	3.55	.136	.50	.9	.03	.00
9	Dec. 30	.85	---do	3.25	.40	.55	1.00	.04	.00
10	Jan. 2	.40	---do	3.60	.08	.36	1.03	.02	Trace
11	Jan. 6	.20	---do	3.55	.24	.45	1.50	.04	.02
12	Jan. 8	6.00	Snow	3.40	.056	.40	0.8	.01	.00
13	Jan. 20	.50	Rain	2.80	.112	.45	.8	.02	.0006
14	Jan. 30	.75	---do	4.00	.056	.40	.9	.15	.012
15	Feb. 15	3.00	Snow	3.50	.35	.45	1.5	.02	Trace
16	Feb. 17	3.00	---do	10.00	.28	.42	2.00	.015	Trace
17	Feb. 19	.33	Rain	11.15	.02	.50	1.7	.020	.0025
18	Feb. 20	1.00	---do	3.50	.056	.43	1.0	.018	.0011
19	Mar. 4	.67	---do	3.60	.06	.36	1.2	.020	.00
20	Mar. 20	4.00	Snow	3.55	.08	.42	2.3	.03	.0039
21	Mar. 22	.10	Rain	3.55	.24	.46	2.2	.055	.28
22	Mar. 24	.60	---do	3.60	.20	.40	.6	.025	.008
23	Apr. 2	4.00	Snow	3.00	.056	.42	.5	.015	.008
24	Apr. 3	1.00	Rain	7.00	.136	.45	.136	.025	.010
25	Apr. 5	.30	---do	3.25	.25	.20	.4	.02	.007
26	Apr. 7	.25	---do	3.50	.40	.45	.6	.0175	.005
27	Apr. 15	.17	---do	1.42	.48	.20	.75	.05	.004
28	Apr. 21	.80	---do	7.10	.42	.35	.70	.04	.0045
29	Apr. 24	.20	---do	3.50	.35	.48	.75	.055	.0044
30	Apr. 25	.15	---do	4.00	.36	.20	.5	.035	.006
31	Apr. 28	.20	---do	2.9	.136	.45	.7	.053	.004
32	Apr. 29	.60	---do	2.13	.24	.44	1.2	.036	.0008
33	May 2	1.00	---do	1.42	.40	.32	.3	.04	.0006
34	May 3	.30	---do	1.05	.18	.36	.63	.025	.00
35	May 4	.33	---do	0.75	.28	.28	.40	.045	.0044
36	May 11	.60	---do	2.75	.32	.20	.70	.05	.0007
37	May 15	.20	---do	0.71	.32	.24	.80	.05	.0044
38	May 18	.20	---do	2.00	.35	.24	1.1	.065	.0038
39	May 20	.33	---do	0.9	.04	.42	.45	.06	.003
40	May 27	1.25	---do	0.7	.136	.20	.72	.074	.002
41	June 2	.17	---do	3.55	.40	.42	.68	.07	.003
42	June 5	.38	---do	3.00	.36	.35	.65	.04	.001